If you are using a printed copy of this procedure, and not the on-screen version, then you MUST make sure the dates at the bottom of the printed copy and the on-screen version match.
The on-screen version of the Collider-Accelerator Department Procedure is the Official Version.
Hard copies of all signed, official, C-A Operating Procedures are kept on file in the C-A ESHQ Training Office, Bldg. 911A.

C-A OPERATIONS PROCEDURES MANUAL

8.3.5 Turbomolecular Pump Station (TMPS) Operation

Text Pages 2 through 15

Attachments

Hand Processed Changes

HPC No.	Date	Page Nos.	Initials

Approved: ***Signature on File*** _____
Collider-Accelerator Department Chairman Date

D. Weiss

8.3.5 Turbomolecular Pump Station (TMPS) Operation

1. Purpose and Scope

1.1 This procedure covers operation of the RHIC Turbomolecular Pump Stations (TMPS) used on the RHIC insulating vacuum cryostats. This OPM may be used for a RHIC TMPS installed on any cryostat of the RHIC Collider.

1.2 This procedure covers the use of a TMPS for supplementing pump down and leak checking prior to ring cooldown and for helium pumping to maintain insulating vacuum subsequent to ring cooldown.

1.3 Maintenance and installation are not covered by this OPM. See the Vacuum Technical Supervisor for maintenance and installation requirements

2. Responsibilities

2.1 This procedure is to be executed by properly trained personnel within the Vacuum System Section, and by other trained operations personnel in coordination with the Vacuum Technical Supervisor.

2.2 Persons who operate a TMPS are responsible for following this procedure.

3. Prerequisites

3.1 All personnel involved in executing this procedure shall have working knowledge of this procedure and the equipment by the Vacuum Technical Supervisor.

3.2 All personnel involved in executing this procedure shall be familiar with the RHIC Cryostat and Permanent TMPS layout, Attachment 1.

3.3 All personnel involved in executing this procedure shall be familiar with the RHIC Turbomolecular Pump (TMP) System Schematic, Attachment 2, and System Installation Drawing, Attachment 3.

3.4 All personnel involved in executing this procedure shall be familiar with the RHIC TMP PET pages. A sample printout is provided in Attachment 4.

3.5 All personnel involved in executing this procedure shall be trained in C-A Access Training.

3.6 A list of personnel trained in this procedure shall be maintained by the Vacuum Technical Supervisor.

4. Precautions

4.1 Avoid accidental bleed-up of cryostats and unnecessary wear on turbomolecular pumps by verifying all connections and settings as prescribed herein, prior to operating the TMPS.

4.2 RHIC TMPS are only effective when the TMP inlet pressure is less than approximately 5 torr. Although successful operation may be possible at higher pressure, the TMPS should not be valved in (i.e. cryostat isolation valve opened) if the cryostat pressure is above 5 torr.

5. Procedure

Caution 1:
Manual Gate Valves (MGV) installed on interconnect pumpout ports prevent bleed-up of cryostats, when closed. To prevent accidental bleed-up of a cryostat, do NOT open the MGV without first following this procedure.

Caution 2:
TMPS logic design protects the TMPS and cryostat vacuum following a complete installation. To protect the TMPS and cryostat vacuum, do NOT attempt to operate a TMPS prior to the completion of the TMPS installation.

5.1 Local Control

Five (5) options exist for local operation of a TMPS. Selection shall be based on Vacuum Technical Supervisor direction, a review of the MGV status, vacuum readings on gauge controller channels CHA1 (Turbo CC, Pcc) and CHB1(Cryostat TC, Ptc).

Option	Mode	MGV	Cryostat and TMP Pressures (Torr)	OPM Section
1.	Power-Up	Close/Open	Not Applicable	5.1.1
2.	Initial Start	Close/Open	Not Applicable	5.1.2
3.	Rough	Open	Ptc$\leq 5x10^{0}$, Pcc= HI or LO	5.1.3
4.	Standard	Open	Ptc$\leq 5x10^{-3}$, Pcc$\leq 5x10^{-4}$ or LO	5.1.4
5.	Shutdown	Open	Not Applicable	5.1.5

Note 1:
LO will indicate if the cold cathode gauge (CCG) electronics are on and the high voltage or signal cable is not connected. Initial Start and Roughing modes as specified herein require disconnection of the high voltage cable from the CHA1 CCG installed on the Cryostat Isolation Valve (CIV). The high voltage must be on with the cable disconnected to permit bypass operation for running the TMPS during higher than normal cryostat pressures.

Note 2:
The CCG high voltage is a Range A hazard. No special procedures are necessary to connect or disconnect the high voltage cable. The high voltage can be switched on and off via gauge controller front panel controls, if desired, prior to connecting or disconnecting the cable.

5.1.1 Power-Up Sequence

This sequence applies for power-up of any RHIC TMPS.

5.1.1.1 Open compressed air supply valve and set regulator to 80 psig.

5.1.1.2 Switch the 3 circuit breakers on the front panel of the bottom TMPS rack to the ON position. Verify power to the station by viewing the illuminated LED next to Mains Power label.

5.1.1.3 Switch the uninterruptable power supply (UPS) power to ON.

5.1.1.4 Switch 24 vdc power supply to ON. Verify the station logic controller (SLC) is operating by viewing the display. The display will indicate the program version and RS-485 communication address.

5.1.1.5 Switch Gauge controller to ON. Place mode switch to pressure.

Note:
The following step can be skipped if proceeding directly to one of the following subsections of 5.1 of this OPM.

5.1.1.6 Switch the TMPS to REMOTE mode by turning and removing the key from the SLC front panel.

5.1.2 Initial Start

This sequence applies to a TMPS with a closed MGV only. The roughing and standard sequences for a TMPS with an open MGV are provided in sections 5.1.3 and 5.1.4.

Caution:
This sequence is required if the cryostat pressure is less than one (1) torr and the MGV is closed. It prevents atmospheric pressure gas between the MGV and CIV from entering a cryostat and spoiling the vacuum or impinging on a TMP rotating at full speed which can accelerate the TMPS maintenance schedule.

5.1.2.1 Verify cryostat pressure by viewing the appropriate Vacuum Gauge PET page and gauge controllers, or consult with the Vacuum Technical Supervisor.

Note:
If the cryostat pressure, as verified in step 5.1.2.1, is greater than 1 torr, open the MGV and proceed to the Roughing mode section 5.1.3.

5.1.2.2 Verify MGV is closed. If not, operate the TMPS in accordance with system pressure criteria for rough or standard mode as established in section 5.1.

5.1.2.3 Switch the TMPS to LOCAL mode by inserting and turning the key on the SLC front panel.

5.1.2.4 Set all gauge controller setpoints to the following:

CHA1: 9.5×10^{-3}	(See notes in section 5.1)
CHA2: 0.0×10^{-10}	(Off, Channel Used on Q21 TMPS only)
CHA3: 0.0×10^{-10}	(Off, Channel Not Used)
CHB1: $>7.6 \times 10^{+2}$	
CHB2: $>7.6 \times 10^{+2}$	

Note 1:
LO will indicate if the cold cathode gauge (CCG) electronics are on and the high voltage or signal cable is not connected. Initial Start and Roughing modes as specified herein require disconnection of the high voltage cable from the CHA1 CCG installed on the Cryostat Isolation Valve (CIV). The high voltage must be on with the cable disconnected to permit bypass operation for running the TMPS during higher than normal cryostat pressures.

Note 2:
Valve (CIV). The high voltage must be on with the cable disconnected to permit bypass operation for running the TMPS during higher than normal cryostat pressures.

Note 3:
Each of the following steps is accomplished by pressing and releasing the button below the corresponding icon on the Station Logic Controller (SLC) front panel.

5.1.2.5 Start the forepump. If time permits, allow the forepump to run for ½ hour or more prior to valving the TMPS into the cryostat. Gas ballast performance improves, by increasing H_2O saturation pressure via pump body heating.

Caution:
To insure that the gases between the MGV and CIV do not impinge on the TMP rotating at high speed, complete steps 5.1.2.6 through 5.1.2.8 within approximately one (1) minute.

5.1.2.6 Start the TMP, and verify TMP is accelerating.

Note:
Two LEDs (H1 & H2) are located behind the front panel of the TCP120. H1 illuminates if the TMP is accelerating. H2 illuminates once the TMP exceeds 50% normal operating speed.

5.1.2.7 Open the Foreline Isolation Valve (FIV).

5.1.2.8 Open the Cryostat isolation valve.

5.1.2.9 Monitor CHB1 vacuum reading at the gauge controller.

Note:
Once CHB1 indicates pressure less than $1x10^{-3}$ torr, proceed to the next step.

5.1.2.10 Close the Cryostat isolation valve.

5.1.2.11 Open the MGV.

Note:
Once open, the MGV shall remain open unless the TMPS is to be removed from service, or a TMPS leak is discovered, or as otherwise directed by the Vacuum Technical Supervisor.

5.1.2.12 Switch the TMPS to REMOTE mode by turning and removing the key from the SLC front panel.

5.1.2.13 Open the gas ballast valve. Rotate knob between one and 2 full turns.

5.1.3 Rough

This option can be performed anytime after completion of section 5.1.2 of this OPM.

Note:
Refer to paragraph 5.1 herein for selection criteria. This option represents the proper selection if the cryostat is under rough vacuum corresponding to gauge readings of Ptc≤ $5x10^{0}$ and Pcc= HI or LO. Steps 5.1.3.4 through 5.1.3.7 may have to be repeated several times (approximately every 30 minutes) if the cryostat pressure is greater than $2x10^{-1}$ torr.

5.1.3.1 Verify cryostat pressure by viewing the appropriate Vacuum Gauge PET page and gauge controllers, or, consult with the Vacuum Technical Supervisor.

5.1.3.2 Verify MGV is open. If not, start the TMPS in accordance with section 5.1.2, Initial Start procedures. Upon completion of section 5.1.2 return to this step.

5.1.3.3 Switch the TMPS to LOCAL mode by inserting and turning the key on the SLC front panel.

5.1.3.4 Change gauge controller setpoints to the intermediate roughing mode settings:

Note 1:
LO will indicate if the cold cathode gauge (CCG) electronics are on and the high voltage or signal cable is not connected. Initial Start and Roughing modes as specified herein require disconnection of the high voltage cable from the CHA1 CCG installed on the Cryostat Isolation Valve (CIV). The high voltage must be on with the cable disconnected to permit bypass operation for running the TMPS during higher than normal cryostat pressures.

Note 2:
The following values are a range of settings for the Roughing mode. Adjust set points to permit normal function of the TMPS. To protect the cryostat vacuum, reduce set points as system pressures decrease. Minimum Roughing settings equal maximum Standard settings:

Gauge	Maximum	Minimum	
CHA1:	9.5×10^{-3}	9.5×10^{-3}	(See notes in section 5.1)
CHA2:	0.0×10^{-10}	0.0×10^{-10}	(Off, Used for Q21 TMPS only)
CHA3:	0.0×10^{-10}	0.0×10^{-10}	(Off, Channel Not Used)
CHB1:	5.0×10^{0}	1.0×10^{-2}	
CHB2:	$2.0 \times 10^{+1}$	1.0×10^{0}	

Note:
Each of the following steps is accomplished by pressing and releasing the button below the corresponding icon on the SLC front panel.

5.1.3.5 Start the forepump. If time permits, allow the forepump to run for ½ hour or more prior to valving the TMPS into the cryostat. Gas ballast performance improves, by increasing H2O saturation pressure via pump body heating.

Note:
Two LEDs (H1 & H2) are located behind the front panel of the TCP120. H1 illuminates if the TMP is accelerating. H2 illuminates once the TMP exceeds 50% normal operating speed.

5.1.3.6 Start the TMP, and verify TMP is accelerating.

Note:
Perform the following step within 1 minute of starting the TMP to minimize drag on the TMP and enhance pump acceleration.

5.1.3.7 Open the Foreline isolation valve.

Note:
To insure TMP reaches 100 % speed, wait at least 1 minutes after H2 illuminates before proceeding to the next step.

5.1.3.8 Open the Cryostat isolation valve.

5.1.3.9 Switch the TMPS to REMOTE mode by turning and removing the key from the SLC front panel.

5.1.3.10 Open the gas ballast valve. Rotate knob 1 to 2 full turns.

5.1.4 Standard

This option can be performed after completion of section 5.1.2 of this OPM..

Note:
Refer to paragraph 5.1 herein for selection criteria. This option represents the proper selection if the cryostat is under high vacuum, with active or impending cryogenics, and corresponds to gauge readings of Ptc≤ $1x10^{-2}$ and Pcc≤ $9.5x10^{-3}$ or LO.

5.1.4.1 Verify cryostat pressure by viewing the appropriate Vacuum Gauge PET page and gauge controllers, or consult with the Vacuum Technical Supervisor.

5.1.4.2 Verify MGV is open. If not, start the TMPS in accordance with section 5.1.2, Initial Start procedures. Upon completion of section 5.1.2 return to this step.

5.1.4.3 Switch the TMPS to LOCAL mode by inserting and turning the key on the SLC front panel.

5.1.4.4 Change the gauge controller setpoints to the Standard mode settings:

Note:
The following values are a range of settings for the Standard mode. Adjust setpoints to permit normal function of the TMPS. To protect the cryostat vacuum, reduce setpoints as system pressures decrease. Maximum Standard settings equal minimum Roughing settings:

Gauge	Maximum	Minimum	
CHA1:	9.5×10^{-3}	5.0×10^{-4}	(See notes in section 5.1)
CHA2:	0.0×10^{-10}	0.0×10^{-10}	(Off, Used for Q21 TMPS only)
CHA3:	0.0×10^{-10}	0.0×10^{-10}	(Off, Channel Not Used)
CHB1:	1.0×10^{-2}	5.0×10^{-3}	
CHB2:	1.0×10^{0}	2.0×10^{-1}	

5.1.4.5 Connect the high voltage cable to the CCG on channel CHA1 and CHA2. See notes in section 5.1.

Note:
Each of the following steps is accomplished by pressing and releasing the button below the corresponding icon on the SLC front panel.

5.1.4.6 Start the forepump. If time permits, allow the forepump to run for ½ hour or more prior to valving the TMPS into the cryostat. Gas ballast performance improves, by increasing H2O saturation pressure via pump body heating.

5.1.4.7 Open gas ballast valve. Rotate knob 1 full turn maximum.

Note:
Two LEDs (H1 & H2) are located behind the front panel of the TCP120. H1 illuminates if the TMP is accelerating. H2 illuminates once the TMP exceeds 50% normal operating speed.

5.1.4.8 Start the TMP, and verify TMP is accelerating.

Note:
Perform the following step within 1 minute of starting the TMP to minimize back pressure on the TMP and enhance pump acceleration.

5.1.4.9 Open the Foreline isolation valve.

Note:
To insure TMP reaches 100 % speed, wait at least 1 minute after H2 illuminates before proceeding to the next step.

5.1.4.10 Open the Cryostat isolation valve. This step can be accomplished remotely at a later time, if the setpoints are not satisfied.

Note:
CHA1 CCG setpoint must be satisfied to complete the previous step.

5.1.4.11 Switch the TMPS to REMOTE mode by turning and removing the key from the SLC front panel.

5.1.5 Shutdown

This represents option 5, which can be performed anytime after completion of section 5.1.2 of this OPM.

5.1.5.1 Switch the TMPS to LOCAL mode by inserting and turning the key on the SLC front panel.

Note:
Each of the following steps is accomplished by pressing and releasing the button below the corresponding icon on the SLC front panel.

5.1.5.2 Close the Cryostat isolation valve.

5.1.5.3 Close the Foreline isolation valve.

5.1.5.4 De-energize the TMP.

Note:
The TMP and UHV manifold from the CIV to the FIV will automatically vent when the TMP speed <40% normal operating speed. TMP deceleration may take several minutes. A manual vent of the TMP section can be performed after the TMP is de-energized by pressing the TMP vent valve button located on the SLC.

5.1.5.5 Perform manual vent if desired.

Note:
Several short vent cycles of 1 second or less are recommended, for manual venting.

5.1.5.6 Close the gas ballast valve located on forepump.

Note:
Unless directed otherwise by the Vacuum Technical supervisor, this is the only time the gas ballast should be closed.

5.1.5.7 De-energize the forepump.

Note:
The foreline, up to the FIV will automatically vent when the forepump is de-energized.

5.1.5.8 Verify all gauges except CHA2 (supplemental Q21 cryostat CCG) and CHB1 (cryostat TCG) indicate 760 torr or greater. Continue with manual vents of the foreline and/or TMP sections, until atmospheric pressure is indicated.

5.1.5.9 Switch the TMPS to REMOTE mode by turning and removing the key from the SLC front panel.

Note:
The MGV shall remain open, unless a leak in the TMPS is discovered, or the TMPS is to be removed from service or as directed otherwise by the Vacuum technical Supervisor.

5.2 Remote Communication and Control

This section combined with C-A-OPM 8.3.2 "Operation of the RHIC Vacuum System Using Control System Consoles", describes how to use the PET system, and to monitor and operate a TMPS remotely.

Note:
To start the X-terminal and access Vacuum system PET pages see C-A-OPM 8.3.2.

There is one Cryostat TMP PET page per sextant, for a total of 6 TMP PET pages. Attachment 1 shows the TMPS groupings for each PET page. Attachment 4 is an annotated printout of a typical TMPS PET page. The PET page updates roughly every 5 seconds.

Each TMPS PET page begins with a summary section. This section provides reply data for each TMPS, including vacuum gauge readings, setpoint statuses, and control mode. Other information in this section includes RS-485 addresses and cryostat port locations.

The detail section of each TMPS PET page is located below the summary section and includes all summary section information plus valve and pump statuses for each TMPS. Remote control of a TMPS is performed in this section. All components are independently controlled. This section provides a group of at least 3 lines for each TMPS. Line one provides the TMPS pressures and gauge controller commands. Line two is the TMPS component command line, and line three is the TMPS component status line. A fourth line appears for each D20-Q21 TMPS and provides the vacuum reading of the supplemental cryostat CCG.

Note:
Remote commands are ONLY accepted by the TMPS, if the TMPS is in REMOTE mode and the embedded TMPS software and hardware interlocks are not violated.

To issue a command, left click on the associated component command field. Select the desired state from the pop-up window. Then middle click to send the command. Alternately, select "Send Cell" from the data pull-down menu.

5.2.1 Start-Up

Note:
If the CHA1 CCG (Turbo CC) indicates "RESET" issue the gauge controller "Turn HV On" command. This will re-establish gauge controller communication and cycle the CCG high voltage to ON. A temporary loss of CHA1 setpoint will result as well.

5.2.1.1 Start Forepump, and verify status.

5.2.1.2 Start TMP, and verify status.

5.2.1.3 Open Foreline isolation valve, and verify status.

5.2.1.4 Monitor "Turbo CC" (CHA1, if available) and "Foreline TC" (CHB2).

Note:
Wait until all setpoints are satisfied to send the open CIV command. If the Turbo CC (CHA1) pressure indicates "LO", the foreline TC (CHB2) should be less than $5x10^{-3}$ torr and the TMP should run for 5 minutes with the FIV OPEN before sending the open CIV command.

5.2.1.5 Open Cryostat isolation valve.

5.2.1.6 Verify the Cryostat isolation valve is open before exiting the PET page.

5.2.2 Shutdown

5.2.2.1 Close Cryostat isolation valve, and verify status.

5.2.2.2 Close Foreline isolation valve, and verify status.

5.2.2.3 Stop TMP, and verify status.

5.2.2.4 Stop Forepump, and verify status.

5.2.2.5 Verify pumps are off and valves are closed before exiting the TMP PET page.

6. Documentation

None

7. References

7.1 C-A-OPM 8.3.2 “Operation of the RHIC Vacuum Systems Using Control System Consoles”.

8. Attachments

8.1 Attachment 1 - RHIC Ring Cryostat and Permanent TMP Layout.

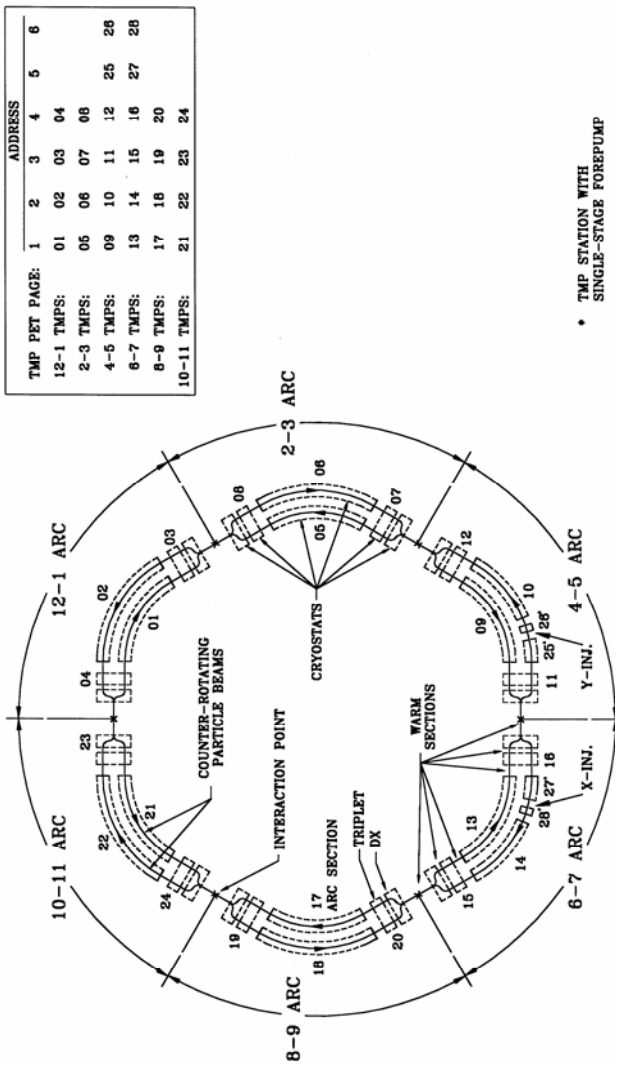
8.2 Attachment 2 - RHIC TMP System Schematic Drawing.

8.3 Attachment 3 - RHIC TMP System Installation Drawing.

8.4 Attachment 4 - RHIC TMP Pet Page (Annotated).

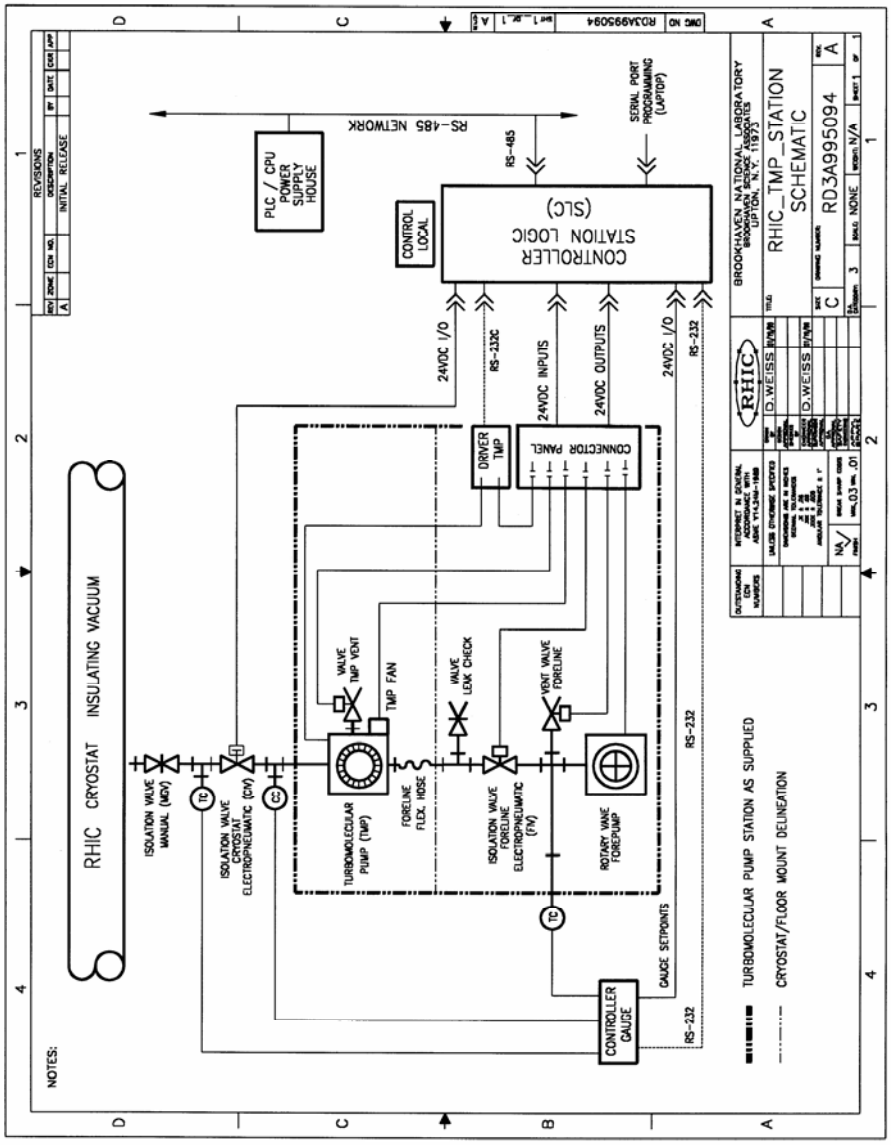
Attachment 1

RHIC Ring Cryostat and Permanent TMP Layout



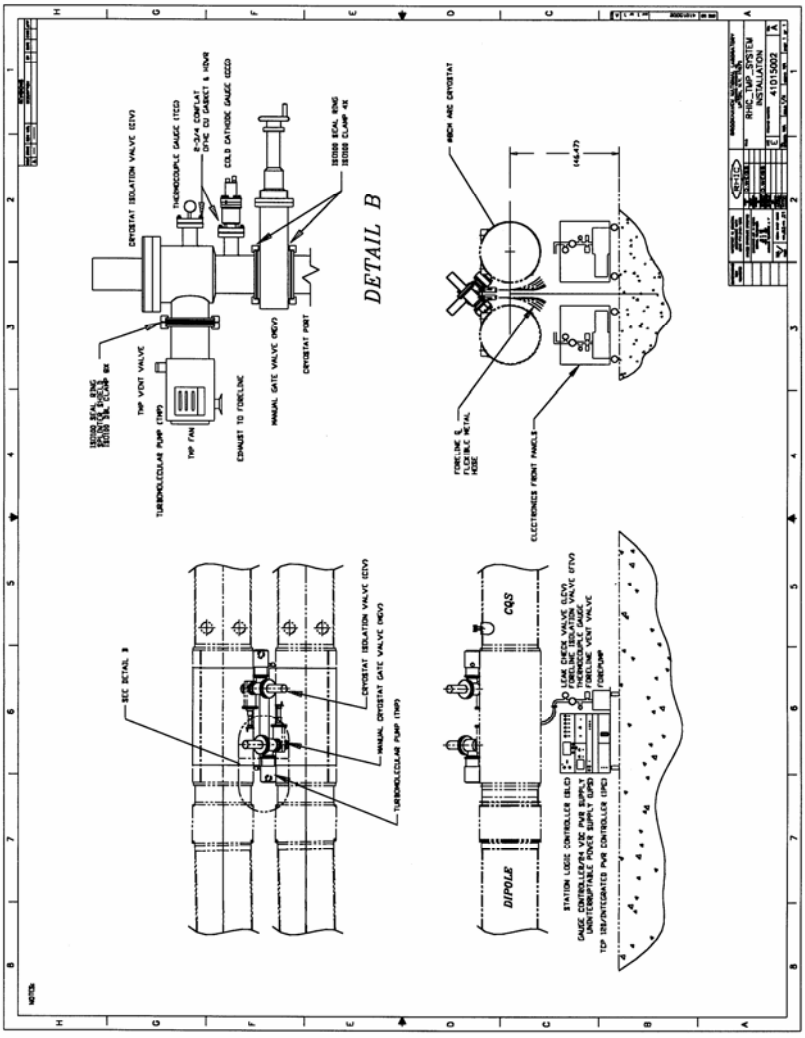
Attachment 2

RHIC TMP System Schematic Drawing



Attachment 3

RHIC TMP System Installation Drawing



Attachment 4

RHIC TMP Pet Page (Annotated)